

REMARKS

The above amendments to the above-captioned application along with the following remarks are being submitted as a full and complete response to the Final Office Action dated November 15, 2005 (U.S. Patent Office Paper No. 20051108), and in conjunction with the Request for Continuing Examination being filed herewith. In view of the above amendments and the following remarks, the Examiner is respectfully requested to give due reconsideration to this application, to indicate the allowability of the claims, and to pass this case to issue.

Status of the Claims

As outlined above, Claims 1 through 13 are currently pending in this application. Claims 1, 3 and 4 are being amended to correct formal errors and to more particularly point out and distinctly claim the subject invention, while new claims 10-13 are being submitted for consideration.

Support for the amendments to the claims may be found throughout the specification, including but not limited to the Abstract of the Disclosure, lines 16-20; and page 5, line 23 to page 6, line 22; page 13, line 20 to page 14, line 2; and page 16, line 19 to page 18, line 2.

It is submitted that no new matter is being introduced through the submission of this response.

Prior Art Rejections

The Examiner rejected claims 1, 3 and 4 under 35 U.S.C. §103(a) as being unpatentable over Li (US Patent No. 6,501,611) in view of Hara et al. (US Patent No. 6,770,386).

The Examiner also rejected claims 5 and 8 under 35 U.S.C. §103(a) as being unpatentable over Li '611 and Hara '386, further in view of Akiyama et al. (US Patent No. 5,949,600).

Further, the Examiner rejected claims 2 and 9 under 35 U.S.C. § 103(a) as being unpatentable over Li '611 and Hara '386, further in view of Gill (US Patent No. 6,650,512); claim 6 over Li '611, Hara '386 and Akiyama '600, further in view of Gill '512; and claim 7 over as being unpatentable over Li '611 and Hara '386, further in view of Kobayashi (US Patent No. 6,687,200).

Applicants have carefully reviewed the above-noted rejections, and hereby

respectfully traverse. The present invention as now recited in claim 1 is directed to a magnetization control method, comprising: providing at least one metal probe; providing on a substrate a multilayer film including a first ferromagnetic metallic layer, a non-magnetic metallic middle layer formed on the first ferromagnetic metallic layer, and a second ferromagnetic metallic layer formed on the non-magnetic metallic middle layer and located facing the at least one metal probe; controlling the distance between the at least one metal probe and the multilayer film so as not to contact the multilayer film; and providing an electric field between the at least one metal probe and the multilayer film to become the height of the potential barrier being effectively high or low compared with a reference value so as to record information to the multilayer film by changing at least one direction of magnetization of the ferromagnetic metallic layers.

The invention as recited in claim 3 is directed to an information recording apparatus, comprising: at least one metal probe, a multilayer film including a first ferromagnetic metallic layer, a middle non-magnetic metallic layer formed on the first ferromagnetic metallic layer, and a second ferromagnetic metallic layer formed on the middle non-magnetic metallic layer and facing the at least one metal probe, wherein the at least one metal probe is structured so that a distance between the at least one metal probe and the multilayer film is controlled so as not to contact the multilayer film, and at the same time an electric field between the at least one metal probe and the multilayer film is provided to become the height of the potential barrier being effectively high or low compared with a reference value for recording information to the multilayer film corresponding to the electric field by changing at least one direction of magnetization of the ferromagnetic metallic layers so as to record information to the multilayer film by changing at least one direction of magnetization of the ferromagnetic metallic layers.

In claim 4, the present invention is directed to an information recording apparatus, comprising: at least one metal probe; a multilayer film comprising a first ferromagnetic metallic layer, a middle non-magnetic metallic layer formed on the first ferromagnetic metallic layer and a second ferromagnetic metallic layer formed on the middle non-magnetic metallic layer and facing the at least one metal probe, wherein the at least one metal probe is structured so that a distance between the at least one metal probe and the multilayer film is controlled so as not to contact the multilayer film; a controller wherein an electric field between the at least one metal probe and the multilayer film is provided to become the height of the potential barrier being effectively high or low compared with a reference value for

recording information to the multilayer film corresponding to the electric field by changing at least one direction of magnetization of the ferromagnetic metallic layers so as to record information to the multilayer film by changing at least one direction of magnetization of the ferromagnetic metallic layers, and wherein the at least one metal probe is structured so that, between the at least one metal probe and the multilayer film, there is applied a voltage for flowing tunnel current through to read information recorded by a change in the tunnel current corresponding to a change in a direction of magnetization due to an electric field which corresponds to the read information.

Further, as recited in new claim 10, the present invention is directed to a magnetization control method, comprising: providing at least one metal probe; providing on a substrate a multilayer film including a first ferromagnetic metallic layer, a non-magnetic metallic middle layer formed on the first ferromagnetic metallic layer, and a second ferromagnetic metallic layer formed on the non-magnetic metallic middle layer and located facing the at least one metal probe; and controlling the distance between the at least metal probe and the multilayer film so as not to contact the multilayer film and providing only an electric field between at least one metal probe and multilayer film to become the height of the potential barrier being effectively high or low compared with a reference value so as to record information to the multilayer film by changing at least one direction of magnetization of the ferromagnetic metallic layers.

Finally, as recited in new claim 12, the present invention is directed to a magnetization control method, comprising: providing at least one metal probe; providing on a substrate a multilayer film including a first ferromagnetic metallic layer, a non-magnetic metallic middle layer formed on the first ferromagnetic metallic layer, and a second ferromagnetic metallic layer formed on the non-magnetic metallic middle layer and located facing the at least one metal probe; and controlling the distance between the at least metal probe and the multilayer film so as not to contact the multilayer film and providing an electric field between at least one metal probe and multilayer film to become the height of the potential barrier being effectively high or low compared with a reference value so as to change a quantum well stage which occurs in the multilayer film to change relative magnetization between the first and the second ferromagnetic metallic layer to record information to the multilayer film by changing at least one direction of magnetization of the ferromagnetic metallic layers.

In the Office Action, the Examiner asserted: "A controller whereby an electric field

between said one metal probe and said multilayer film is provided to . . . for recording information . . . It is obvious to a person of ordinary skill in the art, that when recording is being performed, . . .”.

However, Applicants will point out that commonly used magnetic recording techniques utilize a magnetic field induced by a coil to change the magnetic direction in magnetic media. The present invention, on the other hand, is quite unique and different from the prior art in that it offers a local magnetic recording technique using only electric fields induced between a metal probe and the FM(ferromagnetic)/NM(non-magnetic)/FM trilayers. The present invention does not need to use magnetic fields induced by a coil, which is commonly used to write the magnetic information in magnetic media.

The above-noted advantage of the present invention becomes possible by controlling the magnetic direction by the electric field when using the combination of a metal probe with the FM(1)/NM/FM(2) trilayer media. However, Applicants will contend that this combination of elements would not be obvious to a person having ordinary skill in the art, given the prior art of record.

The FM(1)/NM/FM(2) trilayer media has been well known for the GMR (giant magneto-resistance) effect since the late 1980s. With respect to this type of media, one of ordinary skill in this art would understand that:

- 1) Magnetic coupling between FM(1) and FM(2) can be ferromagnetic, anti-ferromagnetic, and neutral as a function of the NM film thickness, and
- 2) Magnetic coupling between FM(1) and FM(2) can be ferromagnetic, anti-ferromagnetic, and neutral as a function of the FM(1) or FM(2) film thickness.

However, when using the FM/NM/FM media for a storage device, Applicants will point out that it is impossible to change the film thickness of NM or FM films every time one wishes to write or erase the magnetic information.

In the present invention, QW (quantum well) electrons formed in the FM/NM/FM trilayer film are used in that the energy of the QW electrons does not depend only on each film thickness, but on the magnetic directions between FM(1) and FM(2), and also on the boundary conditions of each film. Applicants have found through calculation and experimentation that it is possible to predict the change in the mutual magnetic directions between FM(1) and FM(2) when the energy of the QW is changed. The present invention utilizes the top surface boundary condition called the surface image potential. As is shown in Figure 2 of the application, the stable magnetic coupling between FM(1) and FM(2) films can

be ferromagnetic, anti-ferromagnetic, and neutral as a function of the surface image potential barrier height of the top surface of the trilayer film. Since the surface image potential barrier height can be controlled by the local electric fields induced by the metal probe, it becomes possible to control the local magnetic direction between FM(1) and FM(2) films by way of the electric fields induced by the metal probe.

In contrast to the present invention, Li '611 merely discloses that "Transducer 20 is preferably a magnetoresistive (MR) head" (col. 3, lines 19-20) and "The data recovery feature of the present invention is concerned with the recovery of data when an error is detected in a read signal produced by transducer 20". By definition, the MR head is not a metal probe, and thus Li '611 cannot anticipate or render obvious the structure or use of "at least one metal probe." In addition, Li does not disclose a writing information procedure, but rather reading and correction information procedures.

As such, Li '611 cannot by itself anticipate or render obvious each and every feature of the present invention as now claimed. Rather, the present invention as a whole is distinguishable over the prior art of record.

With respect to the secondary references of Hara '386, Akiyama '600, Gill '512 and Kobayashi '200, Applicants will contend that all of them fall far short of making up for the deficiencies in Li '611 such that any combination of these references would render each and every feature of the present invention as claimed obvious to one of skill in the art. First, Hara '386 is directed to the manufacture of a magnetic recording medium, while Akiyama '600 discloses a probe formed from a ferromagnetic film. Gill '512 discloses a spin valve or GMR sensor, and Kobayashi '200 shows an optical recording system.

Applicants would contend that any combination of the references would fail to show or suggest at least any structure or method wherein at least one metal probe is provided; a substrate having a multilayer film including a first ferromagnetic metallic layer, a non-magnetic metallic middle layer formed on the first ferromagnetic metallic layer, and a second ferromagnetic metallic layer formed on the non-magnetic metallic middle layer and located facing the at least one metal probe are provided; and an electric field is generated between the at least one metal probe and the multilayer film to become the height of the potential barrier being effectively high or low compared with a reference value so as to record information to the multilayer film by changing at least one direction of magnetization of the ferromagnetic metallic layers.

To the extent that any or all of at least these components are shown in the prior art,

none of the references provide any disclosure, teaching or suggestion that would motivate their combination so as to embody a structure or method even remotely similar to those of the present invention. In particular, since the prior art references are all directed to conventional structures and operations, Applicants will contend that the motivation for combining the prior art would have to come from the knowledge of the present invention itself. However, it is the well-established rule of law that a rejection based on hindsight knowledge of the invention at issue or on knowledge gleaned from the invention to guide the picking and choosing of elements from various prior art references is improper. Consequently, Applicants will submit that the present invention as claimed is distinguishable and thereby allowable over the prior art of record.

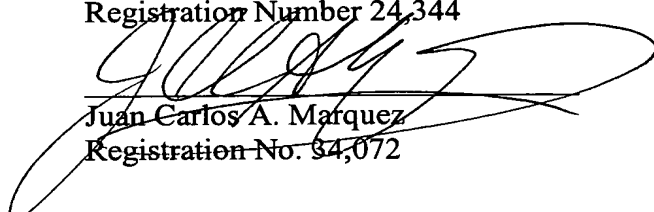
Conclusion

In view of all the above, Applicants respectfully submit that certain clear and distinct differences as discussed exist between the present invention as now claimed and the prior art references upon which the rejections in the Office Action rely. These differences are more than sufficient that the present invention as now claimed would not have been anticipated nor rendered obvious given the prior art. Rather, the present invention as a whole is distinguishable, and thereby allowable over the prior art.

Favorable reconsideration of this application as amended is respectfully solicited. Should there be any outstanding issues requiring discussion that would further the prosecution and allowance of the above-captioned application, the Examiner is invited to contact the Applicants' undersigned representative at the address and telephone number indicated below.

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